**Welding Processes**
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**Welding Nomenclatures**

So we are going to have our last chapter today, so we looked at the entire welding processes, characteristics, physics, so whatever we can use and we did not skip much of them and we covered as much as we could do during this timeframe. So today we are going to look at some of the terms we use in welding opportunity ok. So this is also very important, especially if you are employed in fabrication field where welding is the major Manufacturing process, so these terms you will have to brief properly right. And we looked at some of them, so the terminology we will talk about like HSZ for example ok.

So these are all very simple terms which you are expected to know when you are attending welding metallurgy for example, then you will know all these metallurgical towns which are associated with welding, so what you are going to learn is more of a process later term ok or joint design later terms, so we look at it and then we went up this class right. So the 1st thing when you look at the weld itself, so you make various names we say right for example, butt joint ok.

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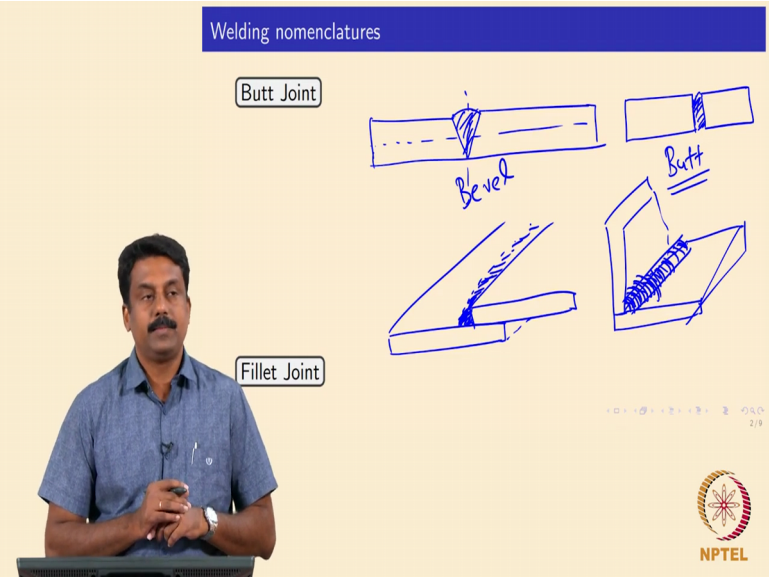


So when you call it is a butt joint, so butt joint when you are joining the 2 flat surfaces or you have joined where the plate thickness is exactly perpendicular to the weld centreline ok. So for example, you make a butt joint so this is butt joint with regroove is not it? So the butt

joint when you do it, you join 2 flat surfaces right so these joints are known as butt joints right. And you can make as the joint design based on the needs and then geometry you need, we will see in subsequent slides what are the joining bevels that are possible and that we commonly use to make butt joints ok, so this machining of the interface is known as bevel ok, and bevel can be V or K double V ok, so where this angle we can use again we will see in the subsequent lectures, so the butt joint is clear right.

And then fillet joint, so fillet generally we use the term fillet joint when the weld centreline and the thickness they are not exactly perpendicular say for example in this case the weld centreline thickness and the surface they are all coplanar, is not it? The thickness, the weld and weld centreline exactly perpendicular in butt joint, whereas in fillet joint so we make joints for example, in overlap configuration so this is overlap joint where so you make the weld using a fillet is not it? Something like this so in overlap configuration, or you can also do in T configuration for example, you can also do T joint ok.

So you can also do joints in T configuration and with a fillet, so fillet means you add in extra material extra layer to make a joint ok. In butt joint you are filling the weld cavities using the filler or in autogenous weld you can also melt and then fill the cavity where as in fillet joint you always have an extra material joint, so in this case it is overlap configuration, is not it? Similarly in T weld you can also make a fillet joint, is not it? So in T joint it is even more clear if you look at this picture.

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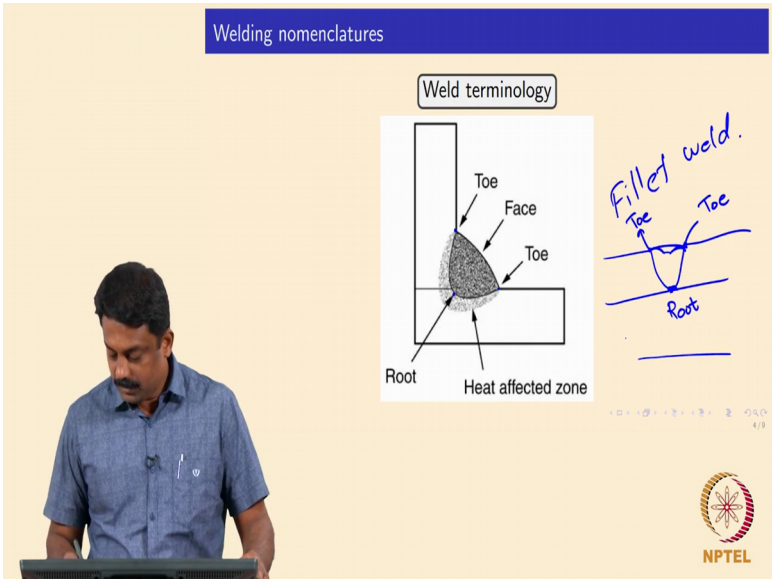

So this is what is the joint? This is T joint with fillet weld, is not it? So in fillet weld so we make fillet fill and then make a joint in T configuration. So in fillet weld, there are some other terms you need to remember, same both in fillet weld, even in butt joints ok and this region is known as root ok, in fillet weld this is the root, so when you are (())(5:10) multipath weld we always do a root pass first with very careful welding procedure because root pass makes sure that the 1st interface is connected without much of distortion and without using cracks for example, our cracks during welding. So root pass for example, if you are doing in a multi pass welds in critical welds, root pass is always done with GTAW okay, root pass the 1st pass to fill the root good cavity right and these regions are known as Toe okay these are toe regions right.

So similarly here this is root, these regions are toes. The toe regions are extremely critical in terms of subsequent mechanic properties of the weld because so when you are depositing multipass fillers so you end up always finishing either at this side or this side, is not it? So if you are not doing the multipass welds and the weld cavities fill properly, this toe regions may always have a notch formation ok. Say for example, we have magnified view and you are feeling withsomething like this and this is your weld. So you see that so when you are not properly filling it up or your pass is not sufficiently (())(6:58) well cavity for example, then you always have a notch formation on weld toe. And this toe region is the region at which you finish the weld at the end, so the (())(7:10) they are always present at the toe regions ok, so toe regions will always contain magnitude of tensile stresses.

So with the presence of the toe notch and the tensile stresses you always see that when the weld is subjected to mechanical loading in cyclic loading there is possibility of crack nucleation from the toe region and subsequently it will progress ok. So if you look at the component failure in the weld by fatigue loading and if the weld is not kidded properly if the weld is not done properly you can always see a crack propagating from the toe region towards the weld centreline. So the moment you identify there is a crack nucleated at the weld toe and subsequently progress, you can always conclude that fatigue could be an issue fatigue loading could be an issue because notch at crack nucleation side and subsequently the presence of tensile stresses at the toe initiate the crack and subsequently the crack can propagate.

So not only fatigue, so this region because of the high tensile region and we also have a dissimilar material is not it? So this is the base material, this is the weld so there could be

some composition mismatch and that can also act as corrosion initiates the region because we have two material, so you may also activate the corrosion at the toe regions ok. So it is very important to know what is toe and we will not go into details about the stress development because we are going to look at it in welding metallurgy, but the terminology should be very family with. The toe region is the region which actually there in the weld face which actually connects the weld prism zone with the (())(9:12) zone, the region of toe, write it is clear ok.

So in T joint also you have the same, in butt joint also will have to see these regions; root, toes and this is the weld face, is it clear? Good.

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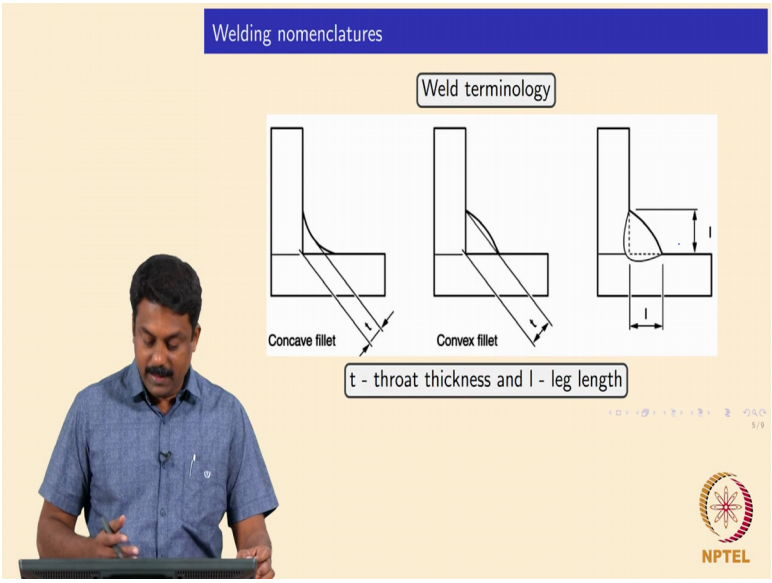


Sometimes some more terminologies so I need to remember for example, in T joints with fillet or any fillet weld, the length L is leg length ok, so the distance between the toe and to the prior interface ok so this region, region from the toe to until the prior interface point, this distance is known as leg length ok. Similarly the thickness, the distance between these regions ok in the convex fillet, and in concave fillet the distance between these 2 regions is known as throat thickness. And this throat thickness is extremely important, same with leg length as well because that is going to determine the amount of pauses we are going to make to achieve or (())(10:44) mechanical properties of the joint ok.

So if the throat thickness and leg length is smaller, and you may not have strong weld because if the thickness is higher the basement thickness is higher and you need to if you are not matching the thickness with the throat thickness and the leg length. And you may have stressed partition or stress concentration on the fillet which may lead to a failure ok. So throat

thickness of the leg length is determined by your base material thickness and the nature of base material what you are going to use, plus the load which is going to be subjected in the weld, clear? Any questions so far?

So these kinds of joints, the T joints in fillets are very common for construction for example, shipbuilding, structures, if you look at the cell construction ok so the pillars, still pillars and bars, they are all welded in T configuration with fillets ok. So based on the thickness of the plates, load bearing capacity and the load which is going to subjected during the commercial operations, we will have to make sure that we have calculated the throat thickness and length properly right clear? Good.

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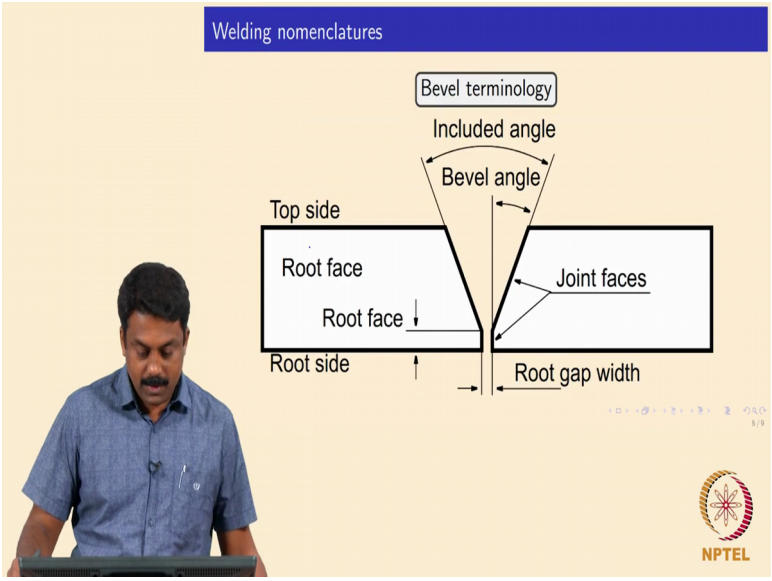


So then bevel terminology, so what is bevel? Bevel is the machining, so how we machine the interfaces ok. So what is important when you are mentioning, say that I want to make bevel at the interface, the important factors are, first is the included angle or the bevel angle okay. So bevel angle is this angle, the angle between weld centreline with the surface so included angle includes both angle that is the included angle. So for example, this top side is the toe side and this is root side, so when you are making bevel, you always as I said the first is the root pas right, and the root pas when you are making it, we also make some root face for the root pass.

So root face the height and the length is known as the root gap width ok, and this is root face and this is root gap width or preset gap ok right, and these are joint faces and the root pass fills the root face and subsequently the conventional the additional process fills the subsequent process. So when you are welding thicker sections, root pass is always we do it in

GTAW, and the remaining can be GMIW or FCIW or SMIW ok because GTAW gives, we control the (())(14:01) right, it is clear so this root side and top side. Any questions? Yes or no? Okay move on.

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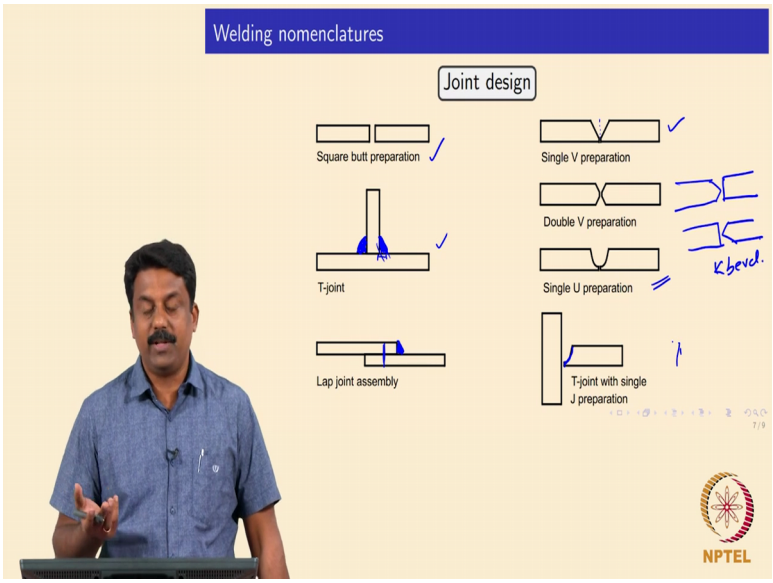


So what are the joint designs? So one thing I showed you already the butt joint right. This is square butt preparation, and butt joints we also have Bevels like single V where you make a single V with an angle ok. And single V is generally done with somewhere lesser thicknesses, but if the thickness of the plate goes higher and we can also go for double V, so why you need double V because we can fill it both sides right, so double V or K is also commonly used, so what is K?

K is you have double V on one side, the other side is flat, is not it? So if you want to have a conventional K letter coming up so you can also make this side flat ok, and then you can make W V in one side, so this is K bevel ok. And K bevel and then double V bevels are used for thicker sections, more than 20 MM or so okay. And there is an old cross-section when V bevel is commonly used ok so there are disadvantages in terms of low distribution. In K bevel you may also note change in stress development and then segregation patterns in K bevel whereas, V bevel you end up building stresses under toe as well as weld segregation at the weld centreline ok.

And this is simply U preparation okay, so the U preparation is basically you prepare with slide elliptical grinding ok. So this is T joint, so T joints are done mostly with fillet ok so this kind of T joints you have a fillet made in both sides ok. And what is the leg length? So this is

leg length and then this is throat thickness. This is lap assembly in overlap configuration, again lap joint if you are doing laser welding you can also do in a spot is not it? And you can also do in a linear, so you can refer my previous slides on the joint design. And conventional GMAW or GTAW with fillet, so you always do with fillet joint so this is lap joint with fillet right, it is clear.

And this is the T joint with single J preparation and this is also sometimes used, so where you have a flat and then in the surface you make a J, so this is J bevel ok. So J bevel means (()) (17:12) of J on the interface clear good so these are simple terminologies I wanted to use right so good.

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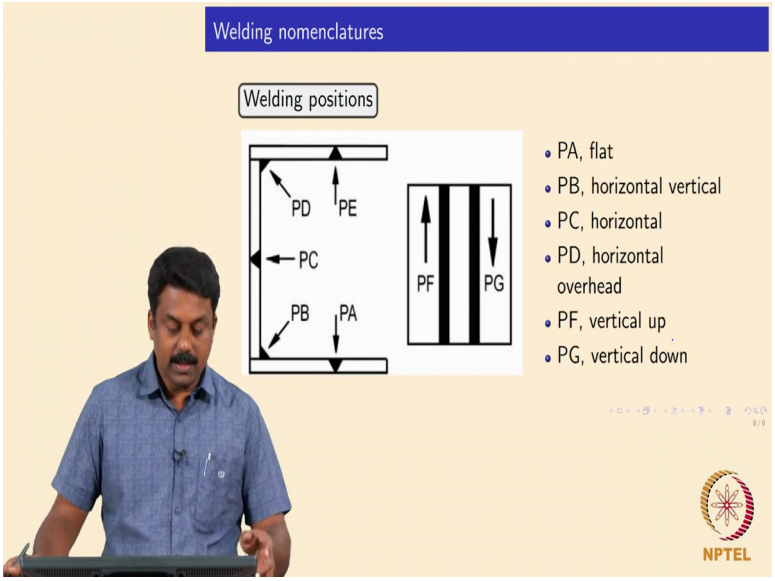


And then welding positions, how do you weld? So you can either weld it in your know down hand or up hand, side and we define welding positions in two terminologies and this is more what you call layman term welding position. You can look at it by looking at the picture, for example PA, PA is a simple flat weld, you do it incomplete down hand okay, you take welding torch or welding torch is mounted and the plate is kept at the flat surface and then you do down hand welding ok and that is known as a flat, it is called PA. PA and PB they are all nomenclatures used by AWS ok. Then PB, PB is for a fillet so horizontal, vertical so because this is horizontal and this is vertical is not it? Ok.

And then PC if you are doing welding, your angle from the side is PC ok. And PD is horizontal but in overhead configuration over here, and then again PF, PG, they are all

vertical, but it will be doing it like in this direction, the other direction, PF and PG ok so yeah.

Student: PF and PG they are this right and PE is something like this.

Professor: Something like this yeah, youwill be doing it like that or you will be doing it like this like that so PF is overhead whereas PG is doing it like that. Yes it is clear? Yes or no? Ok.

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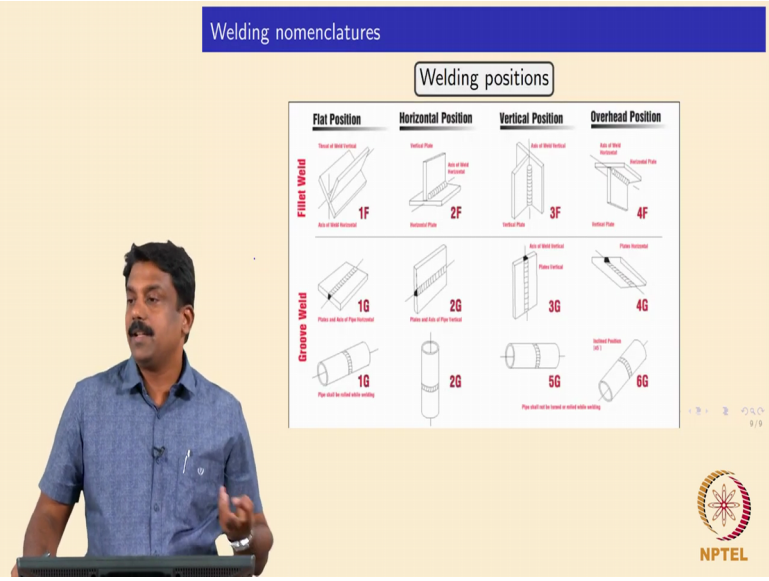


And different terminology by (())(19:30) welding when we use to denote the welding positions by using Gs and Fs ok. So the F denotes fillet weld but the position based on the position we can say 1F, 2F, 3F or 4F. So what is 1F? So 1F is down hand weld, you make fillet ok so something like this ok but 2F is done in horizontal position with the axis of weld is horizontal ok. So in horizontal plate and vertical plate you do a welding fillet like this so that is 2F right, it is clear. Where as in this case the throat is vertical throat of the fillet is vertical ok where here the axis of weld is horizontal, the throat is inclined 45 degree ok. And vertical positions if you are doing it like this okay, so plates are like this and you do it like that so that is 3F and 4F is overhead position, so like this so that is 4F) are for fillet welds.

For groove welds we use G terms ok so G term simple 1G is very simple, in flat plates we do down hand welding, in most of the cases we do it in laboratories, so we make a groove and then deposit that is 1G. And you can also do it in circular geometry, so in this case welding of pipe, when the pipe is rotating ok so you have a pipe, your torch is fixed ok and our pipe is rotating that is also 1G ok. Here we can have a flat plate and then you fix a torch where the plate can move or torch can move that is also 1G. Or you can have pipe, torch is fixed and the

pipe is rotating and you are filling the groove that is also 1G right so that is 1G. 2G is keep the plate vertical and then do a weld in this configuration ok.

So the plate and the torch is 90 degree in this way right so this is 2G right, same can be done for pipe also when the pipes rotating vertically and then you weld. So the pipe is rotating and then you keep the torch stationery then rotate the pipe right so that is 2G, clear.

Student: Even welder around is also 2G?

Professor: No, the welder going around that is 5G ok. If a torch is fixed either the pipe is rotating ok or you keep the plate constant okay and then you move the plate either of the torch that is still 2G only ok. When the torch is moving along the stationary pipe ok or basically torch means welder has to go ok that is 5G ok so the pipes now rotating. So 5G configuration we can easily imagine, it is used for welding long-distance pipe for example, if we want to do offshore pipes welded and then laid onto the sea bottom, how do you rotate the pipe? Is not it? It is not possible because the pipe length can be several thousand kilometres ok, you cannot rotate the pipe, the welder has to rotate or the torch has to rotate, is not it?

So that welding is very challenging because in a single welding operation you will also change the metal transfer characteristics, is not it so gravity changes, so we keep it like this by this side and then we start from here, generally we start from here because it is easy, gravity assist metal transfer, but (())(24:10) change okay you are going around is not it so the metal transfer characteristic can change. So remember what are the forces that assist the transfer? Gravity assist only in down hand welding, so if you are changing the position you also change the forces that assist and test the metal droplets. So when we are doing 5G welds, we will have to make sure that you adapt the welding procedure such a way that the metal transfer is uniform along the circumference in the welding, is not it.

So your welding program should be adaptive as function of the position so that know you do not change the droplet transfer frequency as well as transfer behaviour because the balancing force is always changing is not it? So that is why welding in 5G configuration is most challenging.

Student: So if the pipe is vertical, then we will do it like this…

Professor: It is still 5G, it is still 5G okay, if the pipe is vertical and if you are going around, it is still 5G because the forces are anyway changing.

Student: Gravity is always downwards, and this is going horizontal.

Professor: Yeah but the surface tension can change ok, because you are also changing the plasma jet ok right with respect to the height and position good, it is clear. So then 3G is the flat is yeah pipe is so the plate is like this and then we are welding it right so that is 3G and if you are keeping like this and you are welding like that that is 2G is not it. 3G is more complex than 2G, is not it so 3G you are doing vertical welding right whereas in 2G positions you are doing horizontal welding, so you are not changing the height, the distance, so torch is constant and then it is moving.

If I am doing the vertical movement, the force balances can be different because you are changing the height okay. So the most complex welding procedure is 5G and then 3G value have a flat plate and you are doing vertical welding. And there are more complex which are generally not advisable to do is a complete overhead welding ok so that something like this you weld in plate horizontal position so that is 4G ok. And yeah, practically it is very difficult to do welding in one configuration is 6G position, it is actually very challenging where the pipe is rotating on inclined angle. Sorry when the torch is rotating in inclined angle, pipe is kept in inclined something like this okay.

So you go around, do the weld and inclined pipe ok so metal flow rate behaviour, the transfer behaviour, everything will change. So when the pipe is kept really at an angle and then the welding is done in orbital manner where the welder or the torch goes around and do the welding that is 6G ok. So 6G welding is generally done with extremely trained operators because you will have to make sure that when you are depositing, when you have welding procedure is adjusted for each positions as well as each pass because you need to make sure that when you are depositing, the weld should flow and then you form the fillet without any defects for example, undercuts or overlaps right, it is clear. Any questions so far?

Okay so groove weld, 1G is flat down hand welding, 2G is horizontal welding but plate kept as vertical okay. 3G is plate kept vertical but you do weld also vertically ok, 4G is on a flat plate a complete overhead welding ok so 4G, then 1G in pipe is very simple groove weld, pipe is rotated, it is very easy. So when the pipe is rotated, pipe can be rotated and then torch can be stationary, and then 2G is the pipe is kept vertical ok, still pipe is rotated, reasonable is not it right. And then 5G, so 5G is pipe is horizontal but torch is rotated right it is clear, 6G is pipe is stationery but with an angle, still the torch is rotated around, it is clear, any questions?

Good so then we will wind up okay, hope you enjoyed the classes right, so we will see next time.